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NRL Report 6158

Surface Chemical Methods of Displacing Water and/or Oils and Salvaging Flooded Equipment

Part 3 - Field Experience in Recovering Equipment and Fuselage of HH 52A Helicopter After Submersion at Sea

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PREVIOUS REPORTS IN THIS SERIES

"Part 1 – Practical Applications," H. R. Baker, P. B. Leach, C. R. Singleterry, and W. A. Zisman, NRL Report 5606, February 1961

"Part 2 – Field Experience in Recovering Equipment Damaged by Fire Aboard USS CONSTELLATION and Equipment Subjected to Salt-Spray Acceptance Test," H. R. Baker, P. B. Leach, and C. R. Singleterry, NRL Report 5680, September 1961

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ABSTRACT

The surface chemical techniques previously developed in this Laboratory for the removal of oily and/or electrolyte contamination and the displacement of water from electrical and electronic equipment has been applied to the recovery of the equipment and fuselage of an HH 52A Sikorsky helicopter after immersion in sea water. Satisfactory methods were established for reconditioning the fuselage and wiring harness and other equipment attached to it.

PROBLEM STATUS

This is an interim report; work on this problem is continuing.

AUTHORIZATION

NRL Problem C02-15
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SURFACE CHEMICAL METHODS OF DISPLACING WATER AND/OR OILS AND SALVAGING FLOODED EQUIPMENT

PART 3 - FIELD EXPERIENCE IN RECOVERING EQUIPMENT AND FUSELAGE OF HH 52A HELICOPTER AFTER SUBMERSION AT SEA

INTRODUCTION

In recent years this Laboratory has developed a new procedure for removing oily residues and/or sea water from surfaces (1-6). This principle of displacing oils and water has reduced drying-out time on wet equipment from days to hours. Utilizing these features, a salvage or reconditioning system for oil contaminated and/or wet equipment has been developed. This system (7) was used on a large scale to recondition electrical and electronic assemblies damaged by smoke, soot, sea water, and corrosive vapors during the fire on the aircraft carrier CONSTELLATION in December 1960. Since then, the recovery system has been used extensively by government agencies for routine cleaning of electronic equipment, teletypewriters, etc., to remove contamination by oily aerosols, dust, and spreading lubricants, as well as sea-water salt residues. The system utilizes ultrasonic agitation and/or spray washing as may be required by the complexity and the size of the apparatus. A modification of this system has recently been applied to the salvage of helicopters by the U.S. Coast Guard. The procedures used are discussed in the following sections of this report. More detailed instructions for the salvage of helicopter equipment are provided in the Appendix.

PRELIMINARY TREATMENT OF SUBMERGED EQUIPMENT

In order to salvage equipment satisfactorily after submergence, steps must be taken to minimize the corrosive deterioration which sets in immediately upon removal from sea water. Therefore, shortly after the helicopter was removed from sea water, the fuselage and equipment were thoroughly flushed with fresh water inside and out, then sprayed with the water-displacing composition "Moisture and Rust Control, Type I."* This treatment removed as much water as possible and deposited a protective film to prevent further corrosion. Such preliminary treatment is sufficient to protect the equipment until any necessary inquiry, inspection, or investigation as to the cause of the accident can be completed, and until the equipment can be released for dismantling and salvage.

The power plant of the helicopter was removed from the fuselage and returned to the manufacturer for cleaning and overhaul. The helicopter itself was taken to the U.S. Coast Guard, Aircraft Repair and Supply Base, Elizabeth City, North Carolina, where Mr. P. B. Leach of this Laboratory supervised further salvage operations.

RECONDITIONING PROCEDURE

Because the equipment to be cleaned was relatively free of oily contamination, the emulsion used in the first step of cleaning was made up of 20 vol-% cleaning concentrate and 80 vol-% water (Appendix).

*For chemical composition, see the Appendix.

In order to gain access to the equipment and wiring inside the fuselage, the thermal insulation was removed. Equipment that lent itself to cleaning in an ultrasonic bath was dismantled and removed from the fuselage. The electronic and electrical systems were further disassembled so that each unit would be small enough to clean in the available ultrasonic cleaning tank.

All equipment that could not be reduced to a size suitable for cleaning ultrasonically was opened to gain access for spray cleaning. Various examples of the equipment cleaned, and of the degree of disassembly used, are shown in Figs. 1 and 2. Conventional cleaning equipment, available at the base for cleaning exterior surfaces of aircraft, was used to spray-wash with the cleaning emulsion all surfaces of the helicopter not adaptable to ultrasonic cleaning. After cleaning, all surfaces were rinsed by flushing with fresh water and the excess water was blown off with clean compressed air. The equipment was then sprayed with water-displacing composition "Moisture Control for Electronics, Type II"* and dried with a stream of heated air from an electric heating device.

In order to gain free access to all surfaces of the complicated wiring system of the helicopter for thorough washing, many of the straps and supports holding the wiring to the fuselage were cut (see Fig. 3). The entire interior, including the wiring, junction boxes, etc., were thoroughly washed by spraying with the emulsion cleaner to remove the contaminating sea water. They were then rinsed with fresh water spray.

To make sure that all contaminating sea water and salt residues were removed from the cannon plugs and connectors in the wiring harness, all adapters were opened up to obtain access to the areas where the wire and receptacle pin were soldered. The cannon plugs, switches, and connector assemblies were then cleaned by immersing each, one or a few at a time, in the cleaning emulsion in the ultrasonic cleaning tank. To do this, the ultrasonic cleaning tank was moved to different locations inside and near the fuselage so that the plugs would reach the tank without disassembly from the connecting electrical harness. The adapters were then rinsed in fresh water in the ultrasonic tank, dried by blowing excess water out with compressed air, and sprayed with the water displacing composition, "Moisture Control for Electronics, Type II." These items were allowed to dry at hangar temperatures.

All detachable equipment was cleaned by the ultrasonic procedures described in the Appendix and dried in an oven at 120°F for about 16 hr.

When the equipment was removed from the drying oven it was sent to the Avionics Shop where it was subjected to electronic specification checkout and where any necessary repairs were made before it was released for reinstallation in the helicopter.

Upon removal from sea water, it was found that all magnesium parts of the helicopter had corroded beyond recovery. These were subsequently replaced.

The success encountered in the recovery of this helicopter has led to the use of the salvage system by the Coast Guard on other aircraft suffering similar sea water contamination.

PREVENTION OF DAMAGE TO TRANSISTORS DURING ULTRASONIC TREATMENT

After subjecting transistorized electronic equipment such as the Omni converter (Fig. 1(a)) to ultrasonic radiation, several transistors were found to be defective. It was

*For composition, see the Appendix.

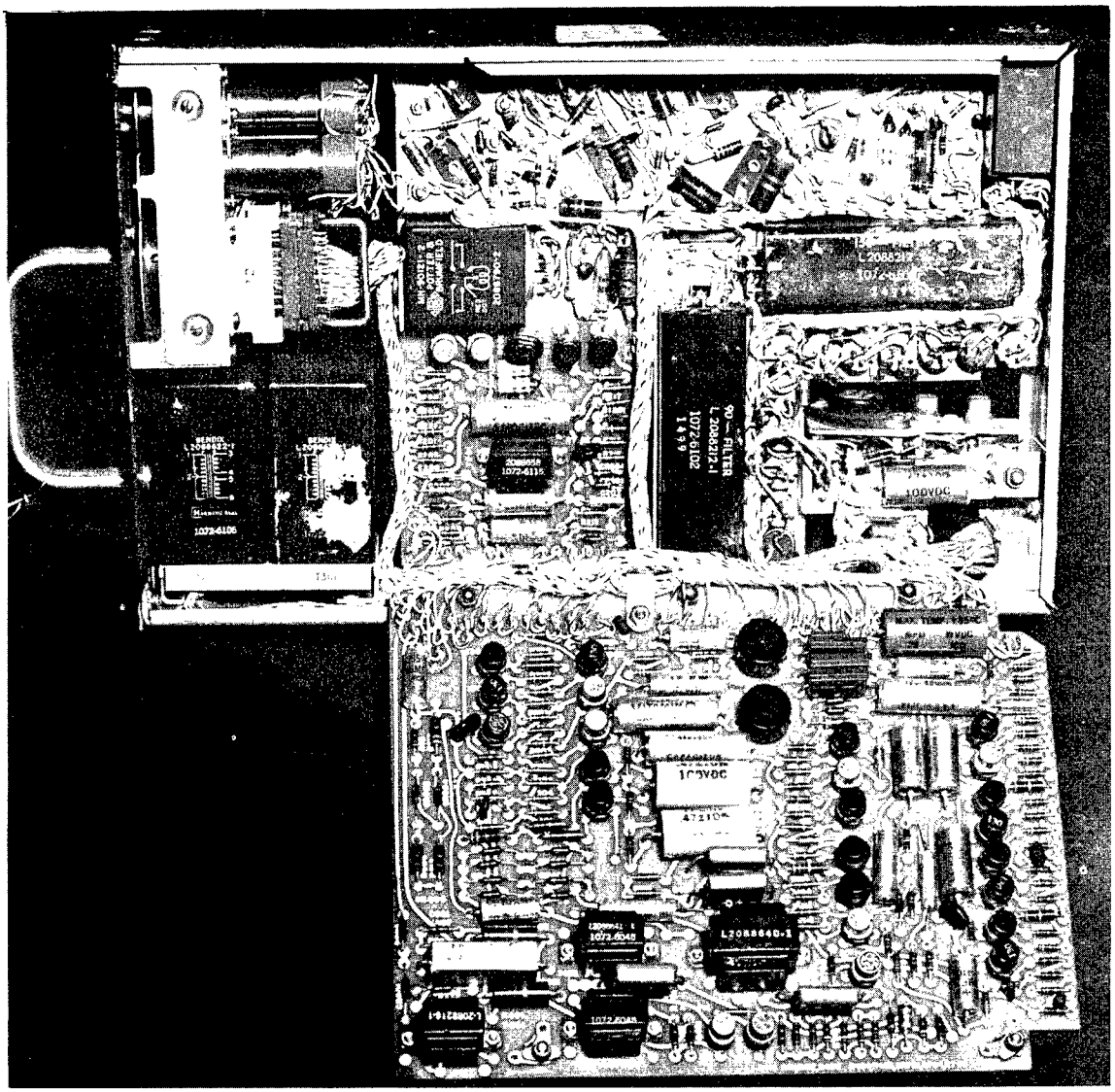

Fig. 1(a) – Example of electronic equipment recovered. The photograph was made after cleaning and is reproduced through the courtesy of the U.S. Coast Guard. NVA-22 Omni-Converter used with R955/ARC 84 Receiver.

later shown that if the equipment was positioned in the cleaning bath so that the ultrasonic waves impinged against the top of the transistors, as illustrated in Fig. 4 (right), they would break down in less than a minute. However, when the equipment was positioned in the cleaning fluid so that the energy waves struck the side of the transistor, as in Fig. 4 (left), no detrimental effect was observed during the cleaning and rinsing cycles.

CONCLUSIONS AND RECOMMENDATIONS

1. Surface chemical salvage procedures have been shown to be effective and profitable for the large-scale recovery of the equipment and fuselage of a helicopter after flooding with sea water.

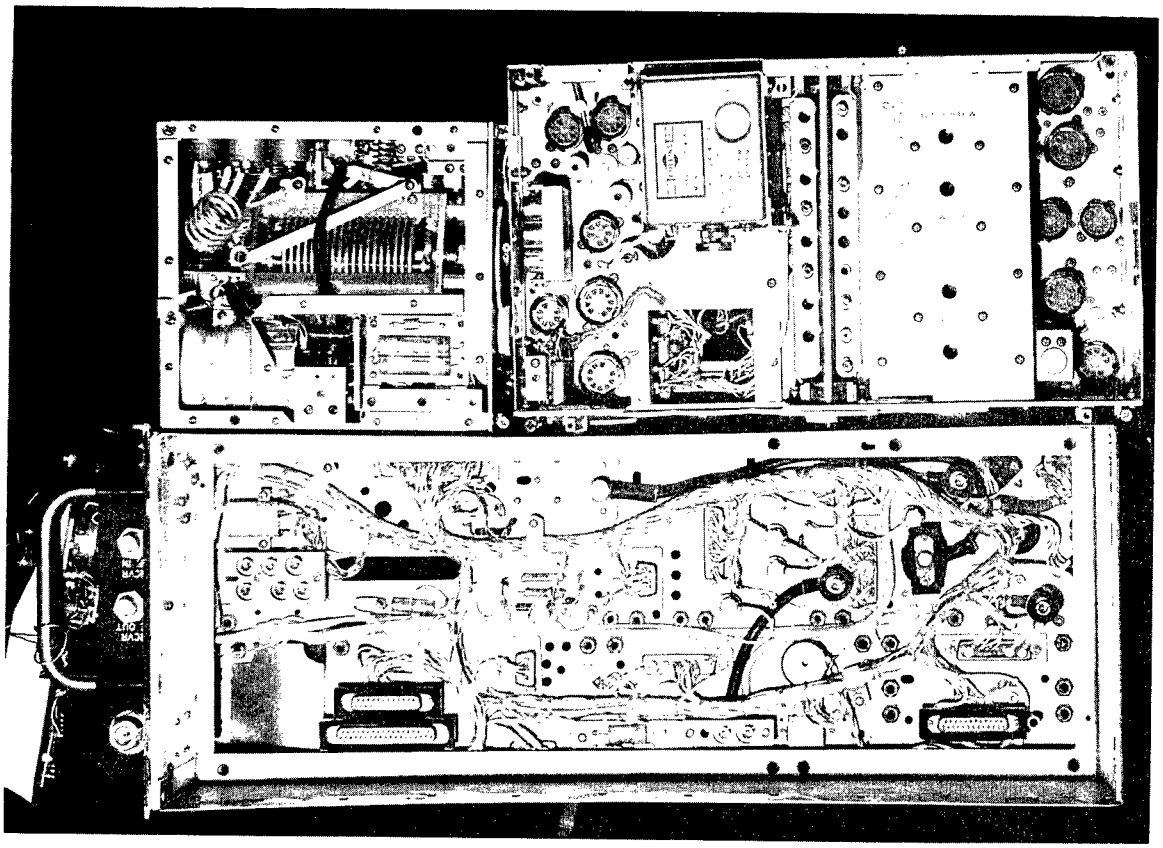

Fig. 1(b) – Example of electronic equipment recovered. The photograph was made after cleaning and is reproduced through the courtesy of the U.S. Coast Guard. HF Transceiver RT 648/2 – ARC 94.

2. The success encountered in this field application indicates promise for these salvage techniques in the recovery of equipment on other types of aircraft after forced landings at sea whenever structural damage is small enough to warrant recovery.

3. It is believed that the overhaul of power plants from submerged aircraft would also be faciliated if the whole engine assembly, immediately after removal from the water, could be spray cleaned with the NRL emulsion cleaner, flushed with fresh water, and then treated with a heavy application of water displacing composition, "Moisture and Rust Control, Type I."

ACKNOWLEDGMENTS

The authors acknowledge with pleasure the cooperation of personnel of the U.S. Coast Guard, Aircraft Repair and Supply Base, Elizabeth City, North Carolina.

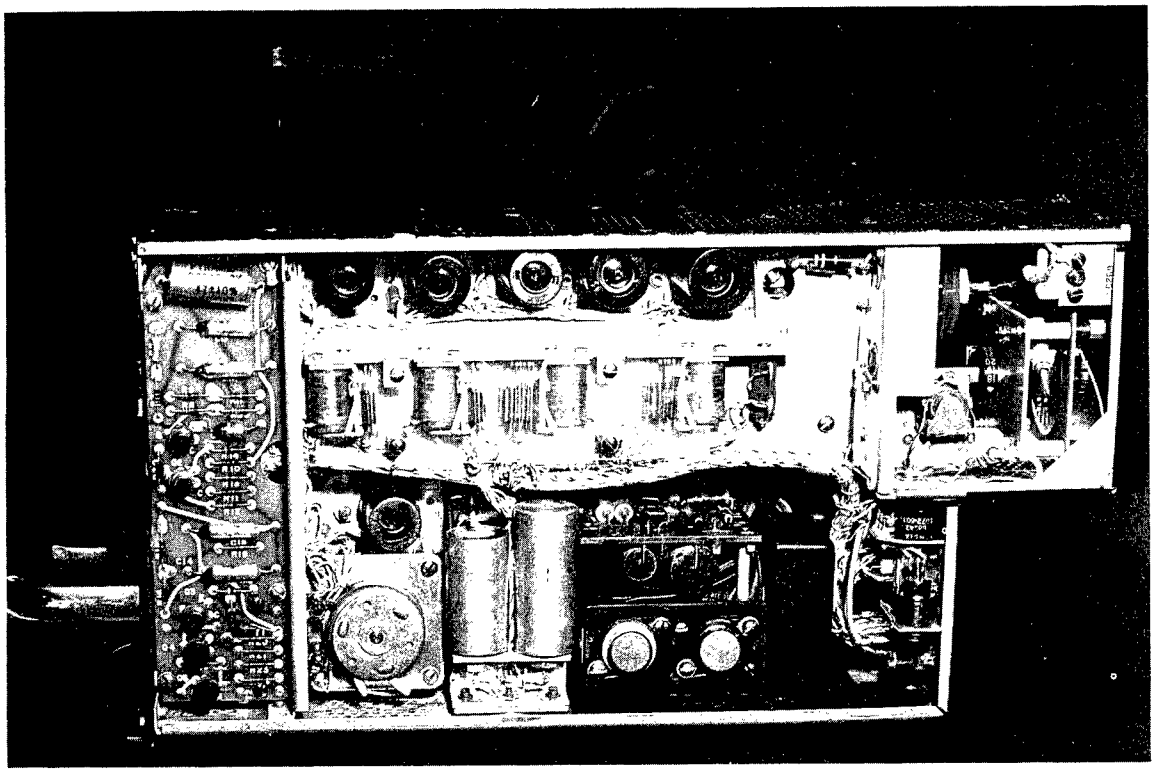

Fig. 1(c) – Example of electronic equipment recovered. The photograph was made after cleaning and is reproduced by courtesy of the U.S. Coast Guard. VHF Transmitter T 744/ARC 84.

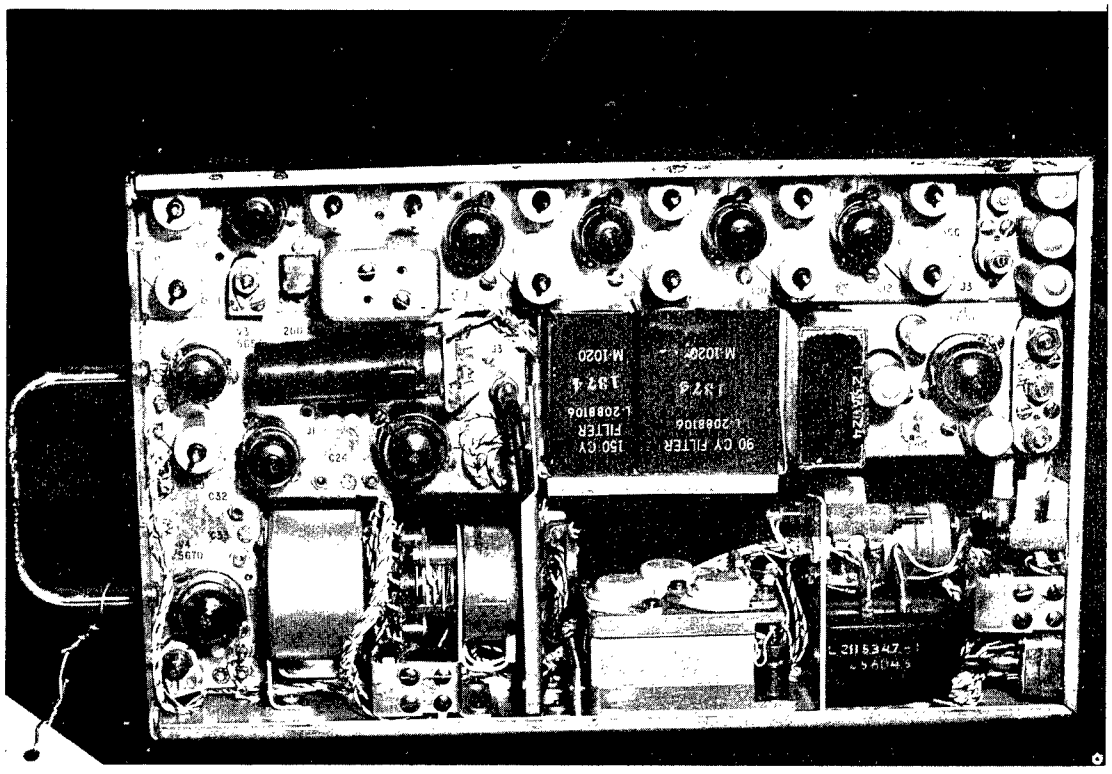

Fig. 1(d) – Example of electronic equipment recovered. The photograph was made after cleaning and is reproduced by courtesy of the U.S. Coast Guard. Glide Slope Receiver GSA-8A-1.

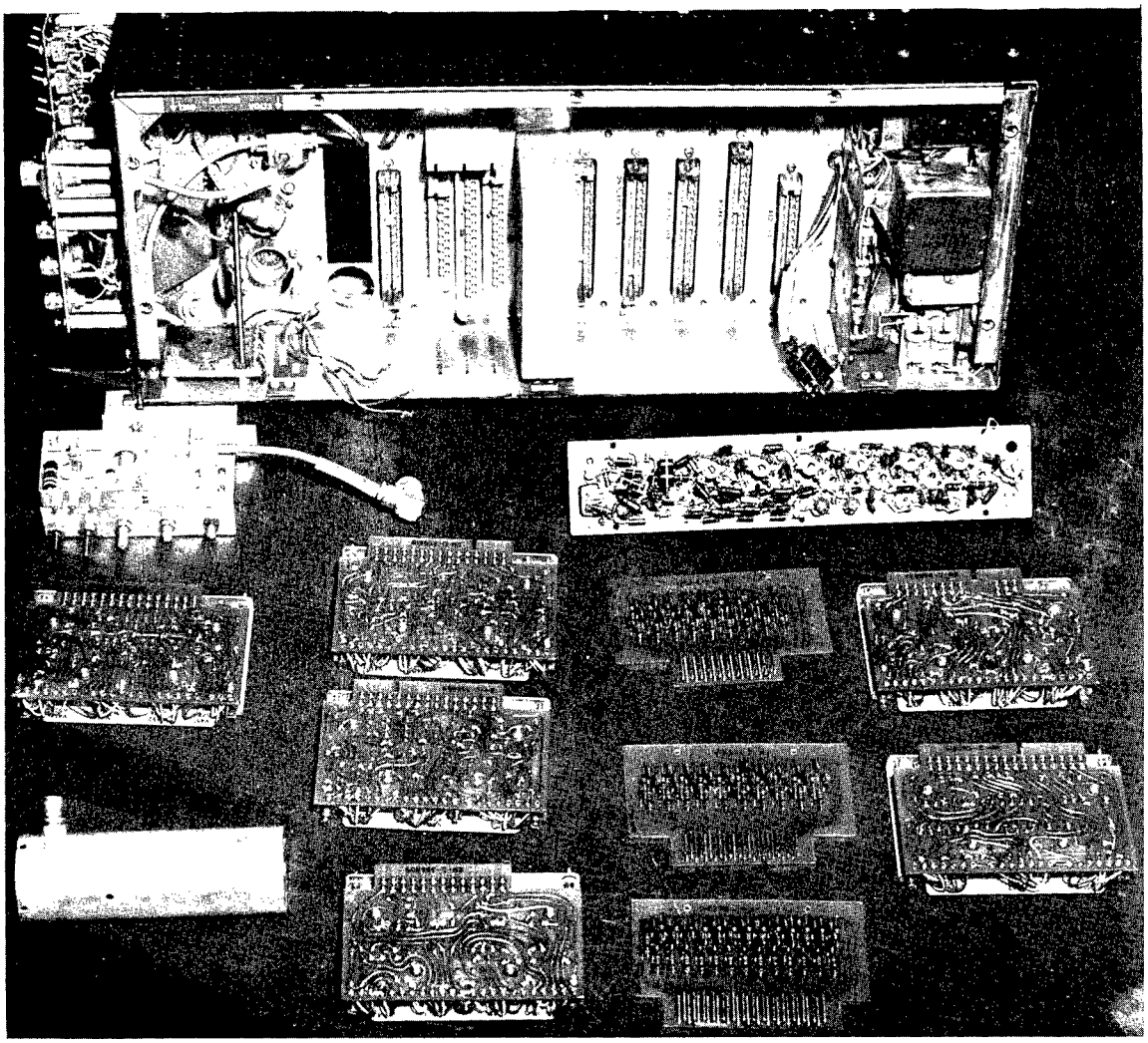

Fig. 2 – Transponder Set AN/APX-44A, IFF (after cleaning).
Photo by courtesy of U.S. Coast Guard.

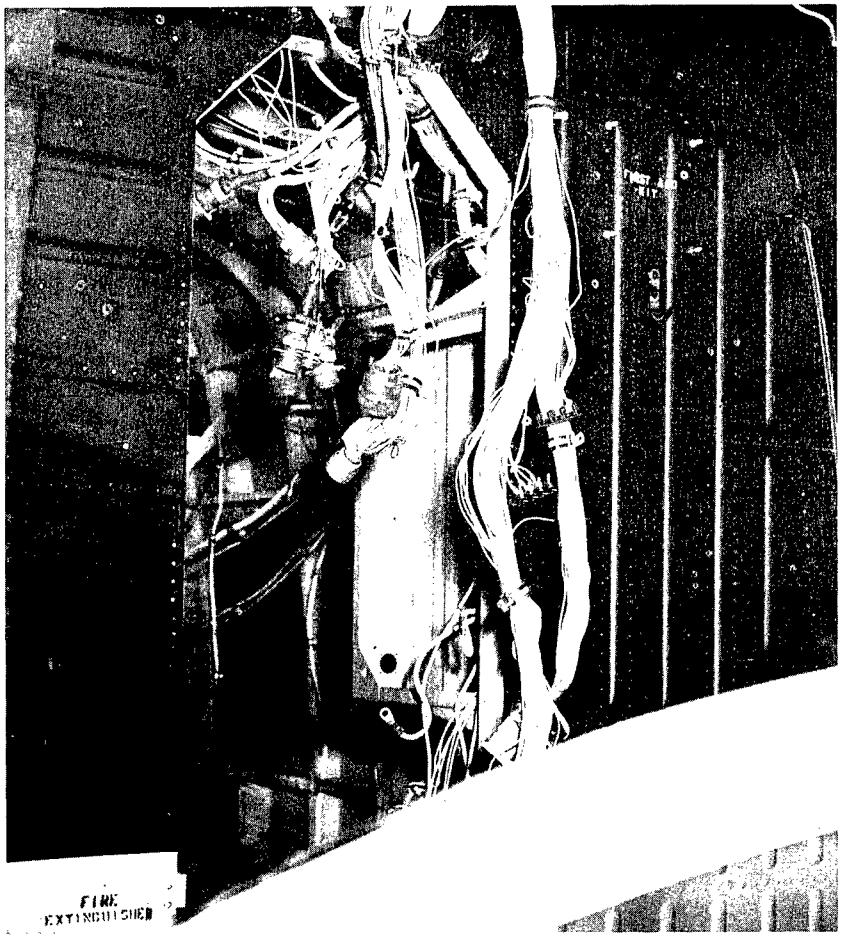

Fig. 3 – Detail of wiring harness, partially loosened for cleaning.
Photo by courtesy of the U.S. Coast Guard.

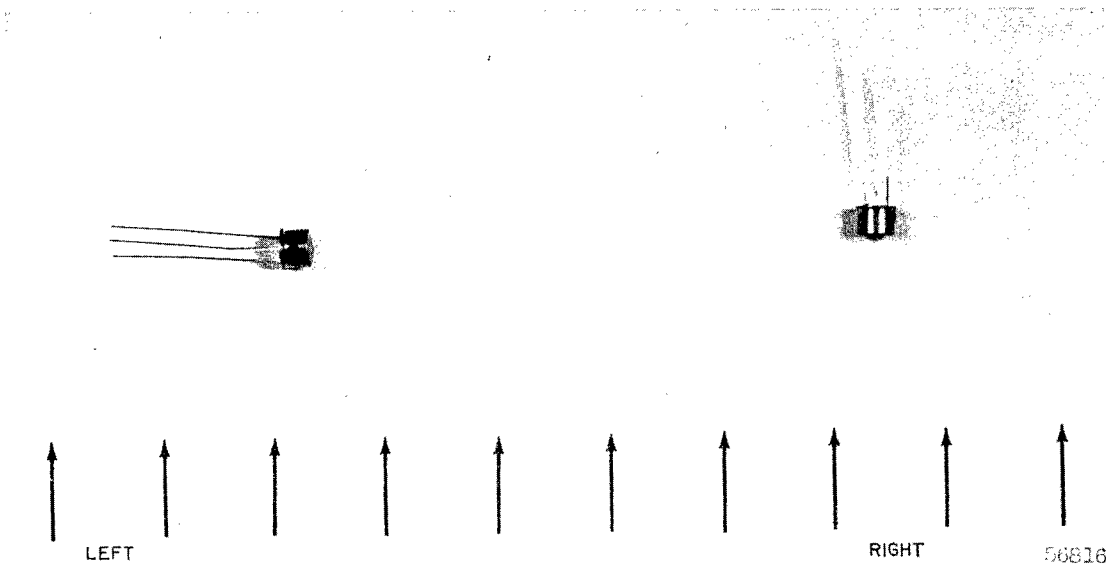

Fig. 4 – Correct (left) and incorrect (right) orientation of transistors with respect to the ultrasonic source during ultrasonic cleaning

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6. Baker, H.R., U.S. Patent 3,078,189 (1963)

7. "Reconditioning of Flooded Equipment," U.S. Navy, Bureau of Ships, Technical Manual, Chapter 19, Section X

APPENDIX

OUTLINE OF PROCEDURE AND FACILITIES FOR RECOVERY OF EQUIPMENT AFTER SEA WATER IMMERSION OR CONTAMINATION

PROCEDURE

On Site Treatment

1. Immediately after removal from the water, flush thoroughly with fresh water.

2. Follow at once with spray of water-displacing, rust-inhibiting composition (Spra-Dri, Moisture and Rust Control, Type I). (This protects equipment during necessary inspection or inquiry, and during transport to repair base.)

Final Reconditioning Procedure (Usually Carried Out at Repair Base)

1. Disassemble enough to allow access of cleaning solutions and to reduce electronic equipment to units of a size permitting immersion in an ultrasonic bath.

2. Remove oily contamination, sea water, and salt with emulsion cleaning composition, in ultrasonic bath. (Pressure spray application or immersion in air-agitated tank may be substituted if circumstances require, but are less efficient.)

3. Flush with fresh-water spray or dip to remove emulsion cleaner, and rinse in ultrasonic bath of fresh water (if possible).

4. Blow rinse water off equipment with clean compressed air and follow with spray of water-displacing composition (Spra-Dri, Moisture Control, for Electronics, Type II).

5. Dry in oven at 120° to 160° F for several hours or overnight. When oven cannot be used, a portable hot air blower may be substituted, or the equipment may be allowed to dry at room temperature for a longer time.

6. Electrical or electronic equipment should be checked for proper operation, defective components replaced, and adjustments made before returning it to service.

EQUIPMENT AND CHEMICALS REQUIRED FOR SALVAGE PROCEDURES

Equipment

1. Spray Equipment

(a) Pressurized tap water or an auxiliary tank with a pump and spray equipment to spray fresh water.

(b) A paint-spray gun or other spraying equipment for applying displacing liquid in a fine mist.

2. Ultrasonic Cleaning Bath

An ultrasonic cleaning apparatus with a power rating of at least 5 w/in.^{2} and a cleaning tank at least 14 in. wide, 20 in. long, and 12 in. deep. Two galvanized steel tanks at least 14 by 20 by 12 in. for alternate use with air agitation can be used if ultrasonic equipment is not available.

3. Rinse and Storage Tanks

Two to four galvanized steel tanks, at least 16 in. in diameter and 20 in. deep, for storing fresh water and/or emulsion-cleaning composition.

4. Clean Compressed Air Supply

Clean compressed air supply or high velocity cold air blower for removal of rinse water.

5. Drying Equipment

Drying oven with temperature control and/or portable hot air blower for final drying of salvaged equipment.

Chemicals

1. Water-Displacing, Rust-Inhibiting Composition (Moisture and Rust Control, Type I)

This composition is commercially available in pressurized aerosol cans or in drums from the Spra-Dri Company, Division of Perfecting Service Company, Charlotte 6, N. C. under the designation "Spra-Dri – Moisture and Rust Control Type I." The water-displacing formulation Type I is formulated as follows:

n-butyl alcohol (1-butanol)	93.75 wt-%
2,6 ditertiarybutyl, 4-methylphenol *	0.25 wt-%
basic barium dinonylnaphthalene sulfonate † (50% inhibitor concentrate in naphtha)	6.00 wt-%
	100.00 wt-%.

2. Water-Displacing Composition, Type II

This composition differs from Type I above, by containing less rust inhibitor. It is intended for final water displacement on cleaned electronic equipment. It is available in aerosol cans, 5-gal cans and 55-gal drums as "Spra-Dri" – Moisture Control for Electronics, Type II," from the same source as Type I.

*This is an oxidation inhibitor supplied under the trade name "Parabar 441" and is available from Enjay Chemical Company, a division of Humble Oil and Refining Company, 15 West 51st Street, New York, N. Y.

†This is a rust inhibitor concentrate containing 50% inhibitor in naphtha solution. It is supplied under the trade name Na-Sul BSB by the R. T. Vanderbilt Company, Inc., 230 Park Avenue, New York, N. Y.

This material may also be formulated locally, if desired. It has the following composition:

n-butyl alcohol (1-butanol)	98.75 wt-%
2,6 ditertiarybutyl, 4-methyl phenol*	0.25 wt-%
basic barium dinonylnaphthalene sulfonate† (50% inhibitor concentrate in naphtha)	1.00 wt-%
	100.00 wt-%

The rust inhibitor concentration in this composition is reduced to avoid difficulties with switch contacts. Type II should not be used when maximum rust inhibition is required. Either water-displacing formulation may be prepared locally by dissolving first the oxidation inhibitor and then the rust inhibitor concentrate in the butyl alcohol and mixing thoroughly.

3. Concentrate for Preparation of Emulsion Cleaner

This material has the composition given below:

Dry Cleaning Solvent, Type II, Fed. Spec. P-S-661, Navy Stock No. 55-gal drums W6850-285-8011, 5-gal cans, W 6850-274-5421	91. vol-%
Diesel fuel oil, Type I, Mil. Spec. Mil-F-16884 Ships, Navy Stock No. 5-gal cans WF9140-255-7764	8. vol-%
Surfactant, nonionic	1. vol-%
	100.0 vol-%.

Polyethylene glycol 400 monooleate, S1006, a product of Glyco Products Company, Inc., Empire State Building, New York, N. Y. is the surfactant recommended. However, Detergent, General Purpose, Mil. Spec. Mil-D-16791C-AN1-Type II, Navy Stock No., 5-gal cans, 7930-531-9716, can be used if the surfactant suggested is not available.

The cleaner concentrate is prepared by dissolving the surfactant and the diesel fuel oil in the dry-cleaning solvent. Immediately prior to use, this concentrate is emulsified with water in proportions of from 15 to 50 vol-% depending upon the degree of oily contamination to be removed.

4. Water Softener

The water used for preparing the emulsion cleaner should not have a hardness greater than 10 ppm. If it is harder than that, it is beneficial to add a water softener in the concentrations shown in Fig. A1. The chemical compound designated as tetrasodium ethylenediaminetetraacetate dihydrate is recommended. The dosage of this chelating-type softener may be determined graphically from Fig. A1. This compound is available commercially under several trade names, two of which are Sequestrene NA 4 (supplied by Geigy

*This is an oxidation inhibitor supplied under the trade name "Parabar 441" and is available from Enjay Chemical Company, a division of Humble Oil and Refining Company, 15 West 51st Street, New York, N. Y.

†This is a rust inhibitor concentrate containing 50% inhibitor in naphtha solution. It is supplied under the trade name Na-Sul BSB by the R. T. Vanderbilt Company, Inc., 230 Park Avenue, New York, N. Y.

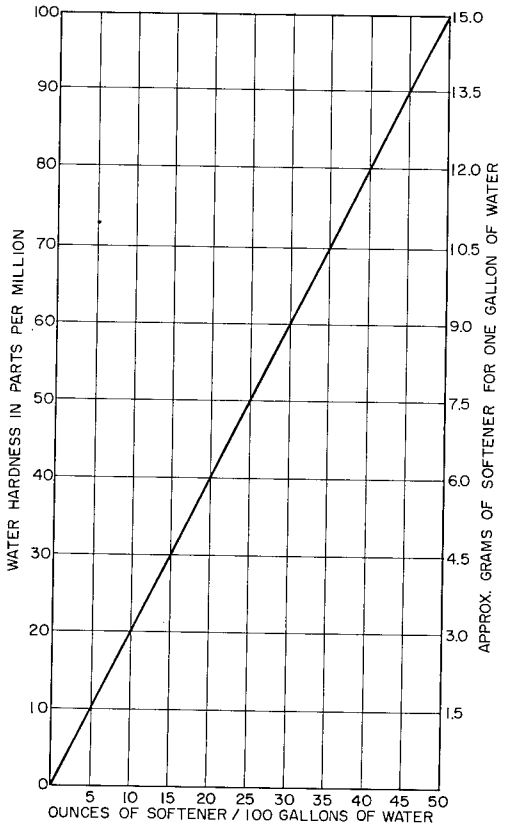

Fig. A1 – Interpolation chart for estimating the amount of tetrasodium ethylenediaminetetraacetate dihydrate required to soften a water of known hardness

Industrial Chemicals, Saw Mill River Road, Ardsley, New York) and Nullapon BF78 (a product of Antara Chemicals, 435 Hudson Street, New York, N. Y.).

5. Brass Brightener

About 1.0 vol-% of household ammonia can also be added to the cleaning emulsion used for cleaning electronic components to help brighten the brass parts of the equipment if desired.

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